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INVESTIGATION OF THE MEASUREMENT OF THE WIND SPEED STANDARD DEVIATION USING A LIDAR (abstract-ID: 383)

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The LiDAR seems to be an effective alternative to met masts measurements of wind profiles. However, as it measures the mean wind speed over a volume increasing with the height, experiments comparing wind speed standard deviation quantified by a LiDAR to anemometers show systematic differences. The purpose of this paper is to investigate the source of this bias in terms of theoretical analysis and simulations.

Conventional methods of assessing the wind resource of a potential wind farm site involve the erection of masts equipped with calibrated cup or sonic anemometers. In order to reduce costs associated with the use of tall masts, the industry requires methods for remotely obtaining accurate wind profiles. LiDAR measurements have shown the significant potential of the instrument for wind measurements. It offers wind industry the ability to determine the wind characteristics at substantial heights using an easily movable ground-based instrument.

Lidar is a remote sensing technique based on the Doppler effect of a laser which is reflected by the particles in the air. By this principle the laser beam enables to measure the radial wind speed. A conical scan of the beam is then necessary to measure the three components of the wind speed. The main difference with a cup anemometer which measures the wind speed at one point is that the lidar wind speed measurement is an average over a volume increasing with the height. This is mainly due to the increasing diameter of the cone on the one hand and to the Lorentzian distribution of the laser power around the focus point on the other hand.

As over a flat terrain the wind field can be assumed homogeneous, the mean horizontal wind speed measured with a LiDAR shows very good comparison to cup anemometers.
However, experiments show a systematic under-estimation of the standard deviation measured by the LiDAR. This paper presents an analytical approach of the quantification of the turbulence with a LiDAR. Moreover, in the experiments comparing LiDAR to anemometers measurements, the LiDAR has been placed about 50m from the met mast. The comparison of the volume average measurement of the LiDAR to what would be measured by an anemometer in the center of the volume has to be simulated. The Mann turbulence model is used to simulate a realistic atmosphere (characterized by wind speed, shear, turbulence and backscatter parameters). The data obtained are then “lidarised”, ie processed with a mathematical transformation in order to simulate what the LiDAR would measure. A number of mean profiles extending from logarithmic to high wind shear will be used as input to the above simulations in order to examine analytically the response of the lidar to the profile changes with height and varying turbulence intensity.